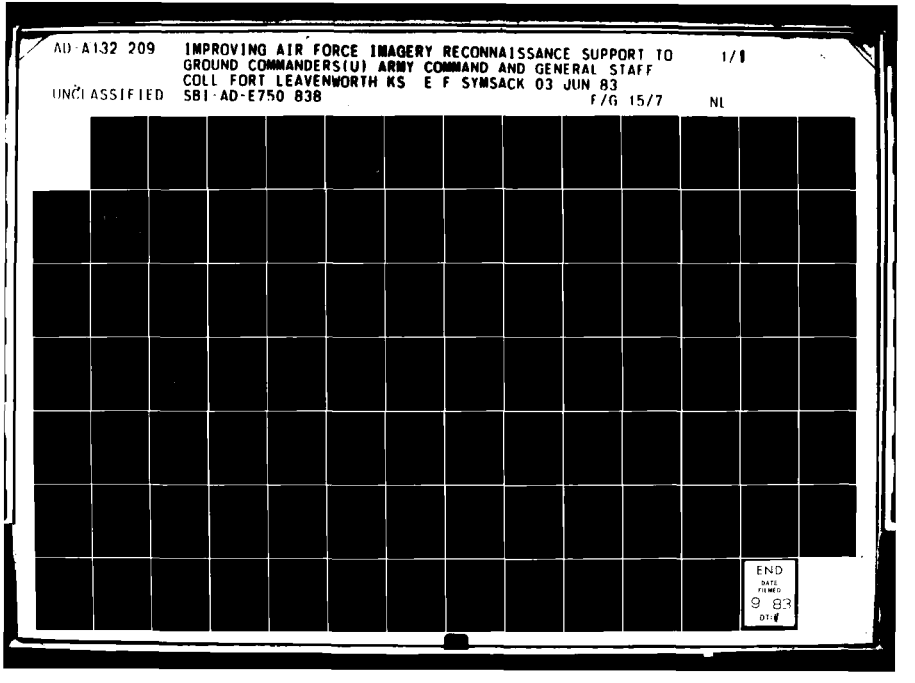
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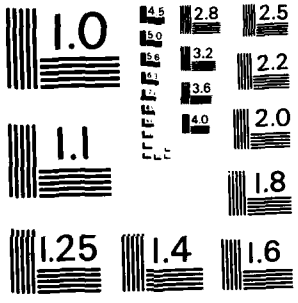

# IMPROVING AIR FORCE IMAGERY RECONNAISSANCE SUPPORT TO GROUND COMMANDERS

A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirements for the degree

MASTER OF MILITARY ART AND SCIENCE

by

ELMER F. SYMSACK, MAJOR, USAF

B.A., University of Tulsa, 1969

Fort Leavenworth, Kansas
1983



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THESIS APPROVAL PAGE

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This thesis examines the evolution of concepts for the development and management of United States Air Force imagery reconnaissance systems and the application of these concepts to current Air Force support to Army ground commanders.

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A generic imagery architectural model is profferred, based upon historic operations and current doctrine. This model includes the following functional components: acquisition sensors, receiver/processors, exploitation elements, transmission/ dissemination media, and recipient processing.

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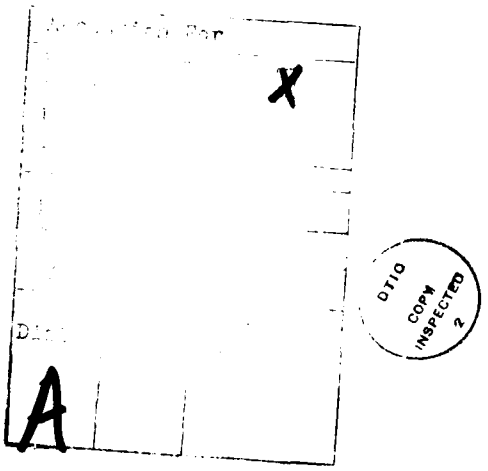

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# CHAPTER I

# INTRODUCTION

## PURPOSE

The purpose of this thesis is to examine the evolution of concepts for the development and management of United States Air Force imagery reconnaissance systems and the application of these concepts to current Air Force support to Army ground commanders. Of specific concern are concepts governing the collection, exploitation and reporting of imagery derived intelligence resulting from wide area imagery reconnaissance and surveillance operations. The intent of this effort is to establish a basis from which improvements can be made in current and programmed Air Force reconnaissance support to the Air Land battle.

This thesis will first examine historical precedents in aerial reconnaissance and reporting. The purpose of this historical review is to provide insight to certain enduring principles of aerial reconnaissance support to ground combat operations. The second objective is to review current management philosophies and guidance which impact the development of both aerial reconnaissance systems and ground

support equipment. These concepts are evolutionary and reflect the application of available technology to perceived ground and air intelligence needs. Lastly, this thesis will examine alternative approaches by the services to reduce the impact of imagery intelligence support as evidenced in the Air Force Intratheater Imagery Transmission System, the Army Tactical Imagery Exploitation System Model, and the Joint Tactical Fusion Program. This paper is not intended as a tutorial on a specific reconnaissance system or of related ground support programs.

The United States continues to improve its tactical imagery reconnaissance capabilities to provide responsive intelligence urgently needed by modern ground commanders to meet and defeat the enemy. The cost of such improvements can be tremendous, in terms of direct dollar costs and the impact upon the success of combat operations. Sophisticated ground support systems and communications requirements particularly, continue to grow in cost, manning and technical complexity. Equally important are the demands such systems levy upon mobility and airlift, and the increased signature they afford to hostile reconnaissance and targeting. The problem therefore is to develop a meaningful way to examine the fundamental use of imagery reconnaissance products and the operational concepts which influence the manner in which we currently develop, acquire and employ major supporting system components.

## HISTORICAL CONCEPTS AND OPERATIONS

Since the French Revolution, aerial reconnaissance has been used to expand the ground combat commander's ability to "see" his enemy's forces and movements. Aerial observer reports enabled the commander and his staff to assess the enemy's strengths and weaknesses, his weapons, movements, use of terrain, lines of communication and fortications. This information increased the surety of the ground commander in estimating his enemy's intent and exploiting his weaknesses. Historically however, aerial observer reports could become confused, and both enemy and friendly movements were obscured or misinterpreted in the heat and confusion of battle. Examination of pilot inflight reports in the Vietnam war and post operation assessment from more recent air combat substantiates this point.[1]

The use of aerial photography, or aerial reconnaissance imagery, was first introduced during the American Civil War. Imagery added new dimensions of accuracy, detail and possible analysis, later to be termed "exploitation", to aerial reconnaisance reporting.[2] Aerial photographs graphically conveyed far more data and provided contextual reference which could be vividly recorded and examined in detail. It was not however, until the First World War that any major effort was made to systematically integrate large scale aerial observation and imagery reconnaissance with ground maneuver operations.[3]

The value, success and rapid evolution of photo reconnaissance in World War I is demonstrated by improvements made by both the Germans and Allied forces. By the close of that war, the German Air Force, which led in the use of aerial reconnaissance aircraft, had over 800 aerial observation and photo reconnaissance aircraft in operation. Rudimentary procedures were developed for aircraft recovery, pilot debriefing, pinpointing and recording observed hostile activity, and communicating the results to effected ground commanders.[4]

Aerial observer and photo reconnaissance reports became integral parts of ground fire support and operational planning. Early reconnaissance operations were similarly adapted to respond to the needs of ground commanders for timeliness and accuracy, and operational constraints in communications, photo processing and recovery and the need for correlation and analysis of photo derived information with other intelligence and operations data. Preliminary results and sketches would be disseminated by courier or dropped directly from the aircraft onto friendly command positions by means of weighted metal message capsules. Precoordinated grid references (Figure 1) and brevity codes were developed to facilitate communication and coordination between aerial units, ground commanders and other combat support elements. These techniques provided reconnaissance units with the means for rapid, succinct position reporting, e.g. "artillery, 200 meters SE of point 16".[5] Similarly,

flares, lights, telephone and later radio reports could be used to expedite mission results from reconnaissance units dislocated from the command elements which they served. Reports would frequently be followed up by ground courier of


Figure 1. WW I German Point Reference Map (Zielpunktkarte)[5]

both written reports or mission summaries and either annotated imagery or imagery derived graphic overlays produced by imagery interpreters.[6]

Near-real-time reports by pilots or observers provided immediate responses to time critical information needs of the supported ground commanders. Imagery interpretation reports provided confirmation, correction or elaboration. Select, exploited imagery provided a more elaborate contextual reference for those same missions. Where there were no available or inadequate maps, imagery was also required for terrain analysis and operational planning.

The priorities and content of reconnaissance reports remained remarkably similar: enemy location and movement, massed formations, artillery concentrations, and the location of friendly forces.

During the years between World War I and II, improvements to reconnaissance aircraft and cameras continued. Employment and reporting techniques however, remained virtually unchanged.

> "During the summer of 1941, Lieutenant General Leslie J. McNair, Commanding General, GHQ, US Army, came to the conclusion, while watching maneuvers, that techniques for the training and employment of observation aircraft were almost identical to those used in 1918." [7]

World War II brought changes in the subordination, control and reporting methods of both Allied and Axis forces. Greater attention was given to search patterns, map

references and both in-flight and ground reporting. Specialized reporting grids, map reference points, and air photo sketches or overlays were again used to convey observer and photo interpretation results. Management techniques had to be introduced to control and disseminate reports from centralized photo interpretation units to varied ground commands to include subordinate, lateral and higher headquarters. These techniques were shaped by limited available communications, a lack of qualified imagery interpreters, and mobility constraints imposed by bulky ground processing and exploitation equipments.[8]

During World War II, major elements of US reconnaissance forces were brought under centralized control at theater and Army level to better manage both limited air assets and intelligence results. It is interesting to note that both Allied and Axis commanders cited friction regarding conflicting requirements between ground tactical commanders requiring immediate support and the more "strategic" needs of their respective air forces. On both sides, limited numbers of observer aircraft remained under the direct operational control of forward commanders to support their needs for immediate (close-in) information. Photo processing and exploitation units, limited in number and hard to move, remained behind.[9]

Several factors appear evident in examining both World War I and II use of reconnaissance imagery. First, that "select" imagery (enlargements or selectively reproduced

parts of the large volume of imagery exposed by the reconnaissance aircraft) became an integral part of the tactical commanders decision tools. And second, the largest single requirement for copies of anything larger than select images (and rather than information derived from the photos) appears to been driven by the the need to supplement or replace inadequate maps of key areas of operation.[10]

Following World War II, little substantive change is evident in Air Force tactical reconnaissance doctrine or equipment. Reconnaissance operations in Korea were characterized by a lack of responsive processing equipment, but overall collection and reporting techniques appear unchanged. The 1962 Cuban Missile Crisis did however focus national attention on the need for more responsive tactical reconnaissance and for improved deployable intelligence processing equipment. To improve the responsiveness of tactical reconnaissance, costly, dedicated courier aircraft were employed to expedite selected imagery to national command centers. Specialized joint service imagery interpretation cells were established to respond to a variety of diverse information needs from air, ground, naval and strategic force commanders.

United States involvement in Vietnam brought limited change in the general support concepts for Air Force imagery reconnaissance operations. In fact, many of the same concerns evidenced by ground commanders in World War II

reappear in correspondance between the Commander-in-Chief, PacificAir Forces and the Commander of 7th Air Force in Vietnam.[11]

> "Army requests for Air Force reconnaissance, especially on high priority targets, continue to diminish. It appears that the Marines also tend to rely more on Mohawk coverage rather than our reconnaissance. The primary reason for decline in requests apparently based on generally slower Air Force response time...of 110 reconnaissance requests, only 25 reportedly arrived on time".[12]

EMERGING MANAGEMENT ISSUES:

The Vietnam conflict did result in a significant increase in technical support requirements surrounding joint service reconnaissance reporting. Three major areas are of particular concern: The development of common joint service imagery exploitation report formats, the initial introduction of automated intelligence support systems, and the capability to electronically transmit imagery from both in-flight reconnaissance aircraft and dissemination on the ground. These technical developments and their evolving employment concepts were aimed at improving overall reconnaissance support. In many ways, they tended to compound or obscure underlying management and reporting problems.

Formatted reporting was originally intended to allow rapid data exchange and computer manipulation of photo reports by successive users. However, rigid editing and machine processing requirements frequently resulted in markedly increased administrative handling by reconnaissance

units which ultimately delayed transmission. The ease with which formatted reports could be manipulated by automated systems soon resulted in expanded requirements for additional formatted data elements to support collection management, targeting and other support activities. Data elements required in a single report by various recipients increased from under a dozen to over 40. This trend was to continue following Vietnam conflict. Formatted reporting largely increased report complexity, compounded communications requirements, and provided little increase in utility for forward ground commanders.

Rather than reexamining the requirement for complex reporting, imagery intelligence production units/activities developed increasingly more complex automated support capabilities. This frequently resulted in only marginal increase in intelligence responsiveness or combat intelligence value.[13]

Technical improvements in imagery transmission capabilities in Southeast Asia led to operational requirements for the retransmission of aerial imagery recovered from Air Force reconnaissance platforms to multiple ground commanders using already saturated wide band communications channels. Management controls to the contrary, this resulted in redundant handling, processing, and expensive support requirements.[14]

Chapter I of this thesis is an introduction and

development of the historical relationship between aerial reconnaissance and supported ground commanders. Chapter II reviews research literature documenting historical precedents and current management concepts and programs which formed the basis of this thesis. Chapters III and IV identify current issues and trends governing contemporary Air Force imagery support to ground commanders. These chapters provide a methodology or basis for examining the relationship between that information required by ground combat commanders and discusses alternative approaches to satisfying his needs. Chapter V presents conclusions and recommendations resulting from this effort.

ENDNOTES

1. James A. Yeager, Major, USAF, Tactical Reconnaissance: Southeast Asia. Air Command and Staff College (Maxwell AFB, AL),1971. pg iii.

2. William E. McDonald, Major USAF, Tactical Air Reconnaissance Operations in Europe and North Africa, (Dec 1941 to Jan 1946). Air Command and Staff College (Maxwell AFB, AL), June, 1967. pg 6-7.

3. Paul Diechman, General der Flieger, German Air Force Operations in Support of the Army. ARNO Press (New York), 1962. The German Air Force began to effectively employ aerial reconnaissance aircraft in ground training and maneuver operations as early as 1911.

4. Ibid.

5. Ibid.

6. Peter Simkins, Air Fighting 1914-18: The Struggle for Air Superiority over the Western Front, Imperial War Museum (London), 1978. pg 74.

7. McDonald, pg 14.

8. Ibid, pg 16.

9. Deichman

10. McDonald, pg 18.

11. Yeager, pg 42.

12. Ibid.

13. Tactical Air Command, Required Operatinal Capability for Tactical Information, Processing, and Interpretation, (Langley AFB, VA), 1976.

14. Training and Doctrine Command (Concept Paper) Tactical Imagery Exploitation: Imagery Intelligence Architecture, 1979.

## CHAPTER II

## REVIEW OF LITERATURE

Literature applicable to this thesis may be divided into the following general categories:

a. Terms of reference: To establish a common frame of reference, a review of fundamental terms is required. Research included a review of accepted fundamental terms within joint service guidance and service doctrine.

b. Historical operations and applications. The preponderance of this type of data deals with the employment of aircraft, cameras, basing and reporting techniques. Review of literature in this area allowed the reconstruction of the content and guidance governing observer reports, photo interpretation reports and the selection and dissemination of imagery.

c. System development programs: An examination of major system development programs provides tangible evidence of trends and the perceived imperatives in contemporary imagery reconnaissance management.

d. Information management initiatives: The United States Air Force has initiated a variety of major programs aimed at assessing the nature of information required to support both air and ground combat information. These assessments and analyses attempt to categorize information into generalized or generic classes and to describe that information by its external attributes, e.g. its volume, frequency, source or the connectivity of its producers and recipients.

TERMS OF REFERENCE:

By definition of the Joint Chiefs of Staff (JCS) Publication 1, Department of Defense Dictionary of Military and Associated Terms, "intelligence is a product resulting from the collection, processing, integration, analysis, evaluation, and interpretation of available information..." Combat intelligence is that "required by a commander in the planning and conduct of combat operations". Photo intelligence, as a major input to combat intelligence includes "the collected products of photographic interpretation, classified and evaluated for intelligence use". Imagery interpretation is defined as "the process of location, recognition, identification, and description of objects, activities, and terrain on imagery". The objective of tactical air reconnaissance is "to obtain information concerning terrain, weather, and the disposition, composition, movement, installations, lines of

communications... of enemy forces".

In Field Manual (FM) 30-5, Combat Intelligence, the United States Army attempts to emphasize diffentiated levels of processing or analysis of data collected on the battlefield by differentiating "combat information" from "combat intelligence" (this distinction is also defined in JCS Publication 1). Combat information is essentially raw data which can be passed to combat users for fire and maneuver without interpretation or analysis. This definition appears in few Air Force intelligence management documents or system operational concepts.

The terms combat information and combat intelligence embrace dimensions of time, breadth of information, and the extent of correlation or analysis of one or more potential sources of information. The distinction between these terms is less apparent when assessing the criticality of information resulting from the interpretation or analysis in imagery. Defense Intelligence Agency (DIA) Manual 57-5, DOD Exploitation of Multi- Sensor Imagery, defines concepts of imagery exploitation and reporting as initial and supplemental based upon tasked mission objectives and extent of detail. This provides little additional insight as to what information resulting from such exploitation is most critical to the supported user of the report.

Current Army concepts for the use of imagery derived intelligence is best exemplified by Headquarters, Training

and Doctrine Command publication, Tactical Imagery Exploitation: Imagery Intelligence Architecture, 1979. This concept paper defines imagery as including the full spectrum of photography: side-looking airborne radar (SLAR), infrared (IR), electro-optical (EO) and microwave radiation (MICRAD). Imagery uniquely provides a high degree of reliability, positional accuracy, and povides unique contextual reference. This concept paper identifies the need for imagery, once processed and made into a usable form, to be retransmitted to additional users. The retransmission of multiple copies or segments of imagery recovered directly from the imaging platform is in response to varying requirements for information (or detail) at separate echelons of command. This concept also identifies the need for adequate, high capacity communications as critical to implementation of the required scheme of dissemination and support.

The United States Air Force is charged by Joint Chiefs of Staff Publication 2, Unified Action of the Armed Forces to "furnish close combat ...support to the Army, to include...aerial photography [and] tactical reconnaissance..." This tasking includes the conduct of reconnaissance operations in support of both land and air operations. Air Force Manual 1-1, Functions and Basic Doctrine of the United States Air Force affirms that "intelligence must be dispatched to all users - to the National Command Authorities, commanders and forces - in time for...effective action".

With cessation of US involvement in Vietnam, the Air Force and Army were able to more fully focus on new requirements which were generated by the growth of Soviet threat forces in Central Europe. As a result of the increasing sophistication and lethality of that threat and the rapidity with which hostilities might be initiated, a series of joint Army and Air Force reconnaissance and surveillance studies was initiated. These efforts resulted in establishing a common frame of reference for reconnaissance and surveillance products, e.g. the relative value of derived information as a result of its timeliness, locational accuracy, frequency of receipt, and the range at which it was collected. Most notable among these combined studies is the 1977 Army - Air Force Reconnaissance Force Study and a mission area analysis of reconnaissance and surveillance conducted by the Air Force Tactical Air Command and Army Training and Doctrine Command in 1976.

HISTORICAL OPERATIONS AND APPLICATIONS:

The use of aerial photography prior to World War I appears to be very limited. Although extensive references are made on the use of aircraft as military observation and artillery control means, photography does not appear to have been widely prior to that time. Paul Deichman, General der Flieger during World War II, in an historical study commissioned by the US Air Force, German Air Force Operations in Support of the Army, provides an excellant description of

German air reconnaissance operations, from World War I and II. He provides an excellant review of employment techniques, reporting, problems in the subordination of reconnaissance units to front line commanders, the methods by which subsequent exchange of information occurred, and the general state of reconnaissance operations due to combat losses and the increasing Allied air superiority.

The use of cameras aboard observer aircraft was initially limited and technical problems such as moisture and aircraft stability prevented extensive operations. We do know that the success of early reconnaissance efforts were in part responsible for the development of early pursuit of fighter aircraft and that improvements continued throughtout the war on reconnaissance aircraft and sensors.

The use of aerial imagery reconnaissance in World War II is well developed by William E. McDonald in his thesis, Tactical Air Reconnaissance Operations in Europe and North Africa, in which he traces the employment of reconnaissance units, methods used to expedite photo products from processing and interpretation units to forward deploying combat forces, the lack of a clearly formulated concept for reconnaissance aviation, and reporting methods. The effectiveness with which imagery reconnaissance was integrated and employed may be best characterized by McDonald's assertion that photo coverage provided conclusive evidence of the German build-up for a major counteroffensive prior to the "Battle of the Bulge".

US Army Air Force correspondance with the Army Command and General Staff School during and immediately following World War II recaps aerial photo operations in Italy and China. Photo requirements differed widely between amphibious, defensive, offensive, infantry, and armored operations. Reproduction requirements, that is, copies of either photographs of specific objectives or photo mosaic coverage of large areas of operation, resulted in the preparation of hundreds of copies of photographs distributed throughout the command.

Unit reports on operations in Italy and prior to the Normandy invasion identify the need to establish special reporting schemes and for the establishment of an ad hoc courier distribution system to expedite the dissemination of photography Imagery was required for the development and coordination of maneuver plans, artillery fire planning and the preparation of maps by engineer elements. Post operation recommendations included the need for separate signal units for photo units - due to the frequent isolation of these elements from advancing combat forces. This separation was largely a result of the more limited mobility and siting requirement for photo reconnaissance and processing elements.

Indicative of the state of reconnaissance support following World War II and prior to Vietnam, is a US Army project report on the results of AIR ASSAULT I, an evalution of aerial observation techniques by ground force

reconnaissance units, and conducted by the Army Test, Evaluation and Control Group, Ft. Benning, Georgia in 1963. This evaluation appears to have been prompted by a need for forward ground commanders to develop an independant capability for responsive, close-in reconnaissance and photography. This project report also identifies the need for "brevity codes" and and an information reporting format to reduce transmission time, insure the completeness and understanding of reports transmitted, and to reduce the volume of information to be transmitted over already overloaded battalion communications nets.

James A. Yeager, in his thesis, Tactical Reconnaissance: Southeast Asia, best characterizes the effectiveness of Air Force tactical air reconnaissance operations during the Vietnam Conflict. His research identifies the extent of those operations, attempts made by the Air Force to provide more responsive support and offers a plausible explanation of why Air Force and Army attention appears to have been focused on aircraft and sensors rather than improving the effectiveness and integration of then existing intelligence capabilities.

In a 1977 thesis, Theater Air Warfare Study: Southeast Asia, developed as a part of the Air War College Theater Air Warfare Studies Program, Kenneth W. Fields, et al, identifies major shortfalls in our reconnaissance support in Southeast Asia due to the long response times of film recovery and

processing capabilities and inadequate command and control of reconnaissance aircraft. Among the major conclusions reached is that to be effective, imagery interpreters ought to be trained as all-source analysts, capable of integrating and understanding both multiple source intelligence data inputs and the operational impact of the activities they observe.

Department of the Army Operations Report - (3-68), 1968, Aerial Observation Lessons Learned, identifies those factors in aerial reconnaissance of primary concern in Vietnam and which differed from World War II and Korean operations. One principle difference was the attainment of air superiority which allowed close-in control of maneuver forces and the ability to discern friendly from hostile ground forces. This report also identified the need for repetitive coverage (observer familiarization) of observed areas as the most effective means of identifying changes or movement of hostile forces.

SYSTEM DEVELOPMENT PROGRAMS:

As a result of the demands placed on Air Force tactical intelligence resources during the Cuban Missile Crisis and the early years of the Vietnam Conflict, the Air Force initiated an extensive program to modernize deployable intelligence support equipments. In Tactical Air Command Required Operational Capability (ROC) for Tactical Information Processing and Interpretation (TIPI), (1967), the tactical air forces concurred in the need for deployable

equipments which included automated photo interpretation support for conventional photo, side-looking airborne radar, infrared and electronic intelligence data. The program focused on improving the performance of imagery interpreters in several critical areas: Providing automated report generation aids (word processing support) required to met stringent formatted report requirements; direct linkage with tactical communications systems; automated data files (historical data bases) to aid in identifying change detection, and specialized interface devices to rapidly calculate aircraft position from ephemeris data recorded on the recovery aircraft imagery. Dispite significant investment and improved interpreter performance, this program did not markedly improve the overall responsiveness of Air Force reconnaissance. It did however, improve the capability of interpretation units to rapidly disseminate the results of its missions to ground commanders using a variety of communications media and thereby shortened overall report dissemination time.

The Air Force also attempted to improve the dissemination of tactical air reconnaissance photo products to ground and air users through initiation of a program for photo quality facsimile transmission devices. The tactical air force requirement was identified in 1970 for a Tactical Imagery Transmission System, later renamed the Intratheater Imagery Transmission System (IITS). Headquarters US Air Forces - Europe Concept of Operation for the IITS (1979),

identifies the need to speed select, exploited imagery (or overlays) from Air Force reconnaissance units to both ground and air tactical units. As affirmed by its Army Imagery Intelligence Architecture however, the Army envisions receipt of imagery near equivalent to that originally recovered from the mission aircraft. These requirements are not incongruous, but they represent extremes in technical requirements, particularly in their relative demands upon communications available to tactical forces.

The period 1974-1977 appears to be a watershed in Air Force concepts for developing the capability to acquire imagery intelligence of ground combat operations. This period may be best characterized by the Air Force Tactical Air Command Concept of Operation for Tactical Air Reconnaissance (1974) which identified the need for employing then available electronic data links to transmit aircraft imagery in "near-real-time" to tactical command centers on the ground. Most notable by omission as a "user" in this concept was the tactical ground force commander. The purpose of imagery so received was to support immediate decision making by air commanders in support of "hunter-killer" operations against enemy ground forces.

Increasing recognition of the importance of combined reconnaissance support to ground commanders subsequently matured in the Air Force Tactical Air Command/Army Training and Doctrine Command Mission Area Analysis of Reconnaissance and Surveillance (1976) and the Army-Air Force Reconnaissance

Force Study (1977). These two works recognized two factors critical to the employment of wide area reconnaissance systems: The information requirements for air and ground commanders differ in terms of identifiable information attributes, and secondly, that the nature and cost of reconnaissance systems demands that information vital to the operation of air and ground forces must be made available to the them, regardless of source, in time and in a form to be effective. While this may appear a statement of an obvious conclusion, the determination of how such information is to be provided has significant cost and operational impacts for both the Army and Air Force.

INFORMATION MANAGEMENT INITIATIVES:

US Army Field Manual 30-5, Combat Intelligence, sets forth the following as a basic principle of intelligence operations:

> "Intelligence must be timely. The best intelligence is valueless unless it reaches the user in time to serve as a basis for appropriate action. Adherence to this principle may involve some sacrifice of completeness and accuracy in the intelligence product."

Essential elements of information are also described as any positive or negative indications of an enemy's activity which might influence a commander's courses of action. The key question is, what is minimum essential information?

FM 30-5 identifies imagery as an excellant means for locating enemy positions and activity, confirming or denying

information received from other less coherent sources, for assessing damage, recognition of deception and counterdeception, identifying enemy equipments and determining accurate locations and measurements. For target acquisition, detection, location, and identification must be accomplished with sufficient detail to permit effective employment of weapons.

J.R. Payne, et al , in a Stanford Research Institute study for the Army Mobility Equipment Research and Development Center, A Classification System and Measures of Effectiveness for Countersurveillance (1971), described an imagery target or objective in terms of those factors which convey substantive intelligence value. A discreet "target element" is the smallest identifiable component of a military force, e.g. a tank or an artillery piece; a "target" consists of one or more target elements which together comprise a single item of interest such as an air defense site or defensive position; and a "target complex" is one or more targets that comprise an activity or force of significant interest. An imagery interpreter might report at each of these levels dependant upon his command tasking, his expertise, and/or his understanding of the operational significance of the objects he observes. This report suggests that imagery interpreters can and do respond to divergent levels of performance and taskings depending upon their understanding of the expected performance. Stated otherwise, interpreters can respond to diverse operational

requirements or situational dependant information needs. This concept has a direct bearing on the potential "sense of the battle" by which an interpreter may identify and report both tasked and bonus information which he understands to be of importance to the recipients of his report.

Defense Intelligence Agency Manual (DIAM) 57-5 and DIAM 58-2, Part 6, Imagery Reconnaissance Objectives Program (IROP), provide management direction and guidance applicable to the joint services for the collection and reporting of imagery intelligence, respectively. Guidance in these manuals is primarily written at the target element or target level. The overall management of collected information and the synthesis and use of imagery derived intelligence is left to the Unified and Specified Commands and services.

Signal magazine is repeatedly quoted in the thesis. This publication proved to be an excellant source for contemporary intelligence related communications and development issues. Major General John Marks, Assistant Chief of Staff, Air Force Intelligence, describes one such major issue in an article for Signal magazine (Oct, 1981): "...we must come to grips with this massive amount of data which our intelligence systems produce....unfortunately, the intelligence analyst is literally buried under this mass of data." Rear Admiral Don Harvey, a former Director of Naval Intelligence, in a Signal article the following month, indicated that analysts were so consumed by maintenance of

complex data systems that intelligence support might be characterized as "analysis untouched by the human mind". Both of these comments consider the total flow of intelligence information of which current imagery intelligence reports are a major segment of the overall volume.

# CHAPTER III

## CONTEMPORARY TRENDS

Today's tactical commanders are confronted with the need to make critical decisions on battlefields of unprecedented fluidity and lethality. Tactical commanders at various echelons of command , the staff elements which support them, and the weapon system crews which execute their commands require information about the enemy in time and in a form usable to support combat operations. The purpose of this chapter is to identify the current needs of ground commanders for imagery and current issues surrounding the support of those needs.

### ARMY USE OF IMAGERY AND IMAGERY DERIVED INTELLIGENCE

Imagery derived intelligence is a key element in supporting a broad spectrum of today's combat decisions and plans. However, "actual imagery is seldom disseminated to the [Army] requestor."[1] US Army Field Manual 30-5, Combat Intelligence identifies the following tactical requirements for imagery and imagery derived intelligence.. This outline is not exhaustive. It does however reflect both the

intensity of modern tactical force needs for imagery and in part represents a basis for characterizing the type of imagery or imagery product required.[2]

- Locating and identifying enemy forces: Imagery is highly effective in determining the precise nature and location of enemy offensive and defensive installations; supply installations and lines of communication; armored, mechanized and personnel concentrations. As an intelligence source, imagery provides reconnaissance not predicated upon enemy emissions or similar cooperation; the enemy must consciously undertake deception or camouflage operations in order to defeat detection. Detailed object identification results from exploitation by trained imagery interpreters. Intrepretation must be accomplished with special equipments. Because of the need to maintain highest fidelity, the exploitation of electronic imagery currently requires significant levels of automation, data transmission and electronic storage capacity.

> "A major role that can be satisfied by imagery is the need to isolate the heart of the critical node for targeting/kill purposes. Available data, drawn from existing studies, leads to the conclusion that only 50 percent of established critical nodes lend themselves to effective electronic templating. The remaining 50 percent must be isolated by other means. Imagery clearly does, or allows, this required isolation."[3]

- Terrain analysis: Imagery records cultural and topographic details which cannot be recorded on maps and allows rapid assimilation of this data by a variety of

decision makers. To be effective, imagery must provide sufficient coverage of objective areas, lines of communication, and surrounding avenues of approach. The need for high resolution is less stringent. Updates or changes to key terrain features may be provided by selected prints or images of those lesser/limited areas.

- Confirming or denying data from other intelligence sources: Because all reconnaissance and surveillance systems can be countered by some means, either active or passive, imagery is most effectively employed in concert with other collection means. In this context, imagery can be used to either cue or direct other surveillance means or to confirm or deny hostile activity identified by them. In its simplest form, confirmation may be a textual report such as "bridge confirmed down" or the location of a known force.

- Reference base for target folders (Decision Graphics): Imagery provides a contextual reference for target analysis, weapon selection, defense analysis, and operational planning. Vivid graphic portrayal of an objective area allows the commander or planner to "see" the battlefield and reach effective tactical decisions on weapons employment and attack. In practice, decision or planning graphics are either select prints or enlargements of specific areas or target activity.

- Battle damage assessment: Rapid accurate assessment of the effectiveness of his attacks enables the tactical

commander to prepare necessary forces for restrike of critical targets or divert precious assets to other requirements. Imagery can record the breadth and extent of damage and can be used to graphically portray the operational impact upon the enemy, e.g. roads blocked, forces or defenses in disarray, or possible enemy withdrawals or preparations for counterattack. Two levels of assessment are assumed here, the first requiring detailed exploitation, the second involving staff or commander's assessment (a type of decision graphic).

- Planning mosaics: The wide area surveillance capabilities of today's imagery sensors allows analysis of entire battlefied sectors, allowing analysis of not only the objective area, but also approaches, potential axis of attack and key terrain or cultural factors which may impact the immediate and subsequent operations.

- Map corrections: Map coverage is limited or non-existant in many areas of the world still. Existing maps may be rapidly outdated by cultural changes or battle damage. Photography is the primary source data for virtually all of today's maps.

- Recognizing deception and counterdeception: Imagery fixes and provides a level of detail unequalled by other reconnaissance means. Detailed analysis and photo mensuration allows the identification of decoys or dummy equipments, positions or activity.

- Identifying major hostile equipments by type, model and/or capability: High resolution imagery can and does provide sufficient clarity to identify equipments and by analysis of disposition or siting, the potential readiness and capabilities of individual equipments or units. Analysis or interpretation of virtually all high resolution imagery requires aided viewing or special enlargement and is normally accomplished by trained imagery interpreters.

- Accurate location and measurements: Precise geopositioning is critical to accurate weapons delivery and maneuver. Bridge and road capacities, weapons identification, defense analysis, and friendly weapons selection can be accurately derived or planned based upon imagery to within feet or inches. Imagery derived target coordinates may be used directly by fire support elements as unevaluated combat information.

IMAGERY SYSTEMS DESIGN

The need for imagery on the modern tactical battlefield is extensive, recurring, and involves a significant variance in imagery products and handling. Functionally, many of the preceding requirements are virtually unchanged since the first military uses of imagery. Techniques and the technical complexity of equipment and communication required to support them has markedly changed however. In order to support this complex need, a variety of management initiatives and system developement programs are currently underway. Each is in response to perceived individual requirements for imagery or

imagery derived information. Improvements include vastly improved imaging sensors, highly automated ground processors, imagery enhancement and interpretation aids, improved means to expedite the preparation of imagery derived reports and the dissemination of both initial mission imagery and selected prints or products. Many of these efforts represent divergent, sometimes conflictings answers to the same need.

Design concepts for imagery ground processing and intelligence dissemination for today's tactical imagery based reconnaissnace systems must respond to the need for balance between collection capabilities and user requirements. During the late 1970's, the Army and Air Force conducted a series of analyses aimed at establishing a point of reference for assessing the information needs of tactical ground commanders.

Figure 2 is a synthesis of one of the most fundamental findings shared as a basic tenet to several such analyses. This figure depicts a multi-dimensional relationship between levels of ground command (company, division, army), the types of hostile activity or objects of most concern at that level (tanks, trucks, airfields, etc), and the characteristics of information needed at each level as a product of time, frequency, level of detail, et cetera. The criteria for measuring the utility of any system or suite of systems was the ability to satisfy "information needs" rather than the delivery of a mission product.

Analyses such as these were largely driven by the need to assess the need for new intelligence collection systems, to include imagery reconnaissance platforms, and to justify the continued operation of a wide variety of existing multi-service collection systems. Far less attention was given to the means or methods by which data resulting from proscribed collection was to be processed, analyzed or disseminated. The TR-1 reconnaissance system illustrates this point.[4]

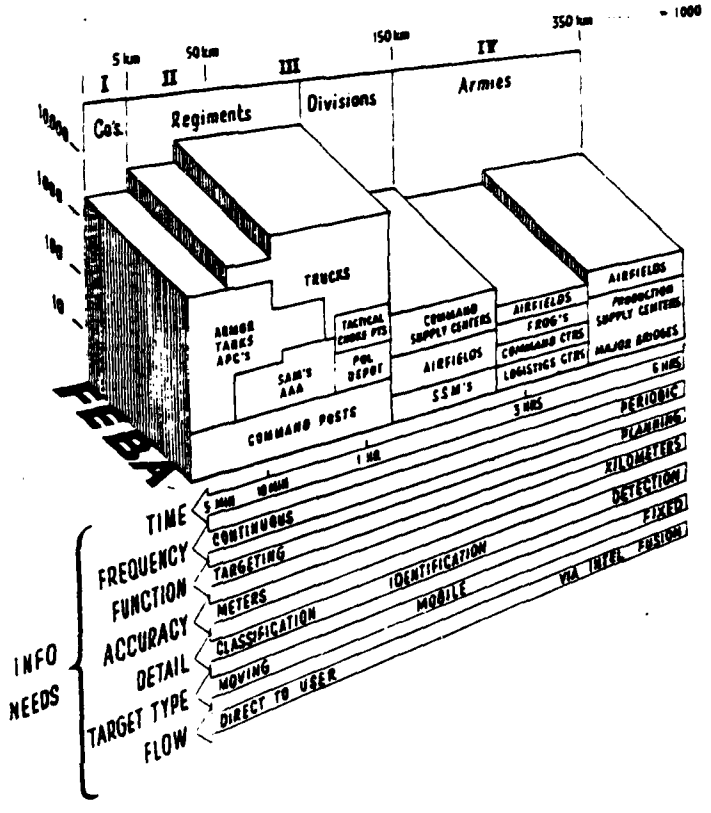


Figure 2. Information Needs of Ground Commanders [5]

The TR-1 tactical reconnaissance system, a variant of the U-2R strategic "spy plane" will be one of the prominent

imagery based collection systems resulting from the joint Army - Air Force Reconnaissance Force Study of 1977. The primary operational requirement behind acquisition of the TR-1 is the need to provide 24 hour all-weather surveillance of hostile forces moving or being massed for attack - to identify their size, disposition, and from that, their potential actions. The primary sensor of this aircraft is a high resolution side-looking radar. The TR-1 capable of imaging hostile forces, equipments and facilities deep inside hostile territory and transmitting its imagery via wide-band electronic signal to a ground receiving station in near-real-time. The resulting "image" however is not a literal one, that is, it is radar image and not a conventional photograph. Overall system design calls for repetitive surveillance of tens of thousands of square miles each day. The introduction of this wide-area reconnaissance and surveillance aircraft into the joint tactical environment exemplifies the profound impact wide area imaging systems have upon Army - Air Force imagery intelligence management.

> "Even though the airframes [of the TR-1 and U-2R] are essentially the same, simply changing the user of the information requires a considerable reeducation effort and modification of long-standing procedures and established lines of information flow. Realignment of information flow is part of a much larger Air Force program to use all intelligence assets more efficiently by making information from national, strategic, and tactical systems more readily available to all commanders who need it."(6)

Employment and design concepts for Air Force imagery and collection and supporting ground systems must be tailored to

reduce the technical and operational impact of collecting imagery of "potentially hundreds of thousands of targets". Although repetitive surveillance and imaging of up to 20,000 - 100,000 square miles of hostile territory may be necessary to prevent surprise and to allow observation of the flow of battle, serious doubt arises as to the need for repetitive receipt of the original (or duplicate) mission imagery by multiple recipients. By absorbing communication channels and other operational resources, e.g. people, dollars and data processing equipments, unnecessary data can have a significant negative effect upon actual system responsiveness.

> "Ideally, what is needed is a single, invulnerable systems that sees the entire battlefield 24 hours a day under all weather and light conditions, filters the information pertinent to the individual commanders needs and instantly transmits all pertinent information directly to the user just as the events are occurring on the battlefield. Such a system does not now exist nor is it likely to in the forseeable future."(7)

Improvements in imagery programs require careful consideration of their overall impact. Each must be predicated upon the relative needs of the combat commander which they are intended to service. In assessing current command, control, communications, and intelligence (C3I) efforts, the Honorable Donald Latham, Deputy Under Secretary of Defense for C3I observed, " There [currently] isn't a well thought through architecture... you have to look at overall system requirements rather than 'parts lists."(8)

There currently is a fundamental imbalance between our ability to collect and effectively use information currently available. In examining the needs of tactical commanders, The Honorable Melvyn Paisley, Assistant Secretary of Navy, Research, Engineering and Systems, indicated that our ability to collect, process, and disseminate critical information continues to exceed our ability to assimilate and comprehend.

> "the most challenging command and control [C3I] problem in the Navy today is managing information....information is not always in the right form or in time....The commander does not want and cannot handle everything....we must decide what information is essential--then tailor our C2 systems to this."(9)

US imagery reconnaissance is an integral part of the C3I information explosion. Traditional silver halide film products, chemically processed and manually distributed are being replaced with electronic near-real-time (NRT) imaging sensors. The term "imagery" now includes not only conventional film based products (black and white, color, camouflage detection and infrared sensitive photography), but also side looking airborne radar (SLAR), synthetic aperture radar (SAR), infrared (IR), electro-optical (EO), and microwave radiation (MICRAD). Virtually all reconnaissance imagery can now be received and disseminated via digital electronic signals simultaneously to multiple locations and replicated with complete fidelity. It appears that a widely held precept of C3I system design is that:

> "Imagery acquired and transmitted by an electronic signal for reconstitution in a softcopy digital format can now become a key factor in developing the combat

commanders's picture of the battlefied." [10]

The critical factors in this observation are "what form of imagery or imagery derived information", "who" needs it and "how" is it to be disseminated. While most reconnaissance imagery is either recovered with the landing of the mission aircraft or data linked to a ground collection and processing station, tactical forces must rely heavily upon tactical and strategic communications means for imagery derived reporting and product dissemination. Electronic relays developed as intregral parts of reconnaissance systems are not functionally unique to those systems. They represent conscious trade-offs for additional communications means. The principal question then becomes how best to assess needs versus potential capabilities.

In 1977, the Defense Intelligence Agency (DIA) established the Defense Steering Group for Systems Supporting the Transmission, Dissemination and Exploitation of Imagery. This forum was intended to provide management oversight and cooperation among the Unified and Specified Commands, their components and the services in balancing imagery related needs and system requirements and development efforts. The effectiveness of this body was soon reduced by the lack of integrated command and service imagery architectural concepts.[11]

## ARMY NEEDS FOR IMAGERY

Based upon now maturing technology, the Army Training

and Doctrine Command began the development of a preliminary imagery architectural concept. This concept, Tactical Imagery Exploitation: Imagery Intelligence Architecture, identifies "how the US Army is approaching the design of [future imagery] developments to enable the tactical commander to 'see' the battlefield." [12] This concept further identifies the need for the receipt and exploitation of imagery by varied echelons of command. As an architecture it capitalizes upon projected requirements and the technical "capability" to rapidly disseminate the full spectrum of imagery electronically and in near-real-time.

The following functional matrix outlines projected tactical Army imagery requirements at division, corps, and echelons above corps (EAC) taken as the requirements baseline of that architecture (Figure 3).[13]

| FUNCTION | EAC | CORPS | DIVISION |
|---|---|---|---|
| Battle Management | | | |
| Sustain the Battle | E1 | E2 | E3 |
| Planning | E1 | E2 | R4 |
| Analysis | E5 | E5 | R4 |
| OPSEC Support | E6 | E6 | E6 |
| Battle Execution | | | |
| Maneuver | N7 | E8 | E8 |
| Fire Support | N7 | E9 | E9 |

Figure 3. Functional Matrix of Army Requirements for Imagery and Imagery Derived Intelligence (13).

Key: E - Imagery exploited at that echelon

R - Imagery reports derived by non-organic exploitation

N - Imagery not required

1 - Hardcopy delivery of imagery adequate

2 - Continuously changing EEI requires exploitation at indicated echelon (electronic transmission of near original quality imagery)

3 - Time most critical for correlation with other NRT data in targeting

4 - Requirement not time sensitive

5 - Analysis is not time critical but must be performed on a frequent and continuous basis

6 - Non time sensitive

7 - Imagery not required.

8 - Exploitation is an iterative process based upon the evolving tactical situation. Function requires close interaction between user and interpreter familiar with the unit's operations and needs.

9 - Imagery and information are time critical. Targets have capability to immediately impact/engage friendly forces. Imagery is required for targeting of immediate threats. Timeliness and level of detail are critical.

Imagery dissemination outlined above is fundamentally governed by "push" distribution. That is, imagery requirements expressed by geographic area or predetermined collection requirements. All reconnaissance imagery acquired under such preestablished requirements would be disseminated

to the indicated echelon or level of command for further exploitation or analysis. Imagery so received can then be integrated with other intelligence data and operational plans to most effectively serve unique, individual command needs. Management of exploitation requirements and resources would be governed by the tactical commander based upon his "sense of the battle" as the tactical situation evolves.

> "If the need for imagery information [by ground tactical commanders] in near-real-time is self-evident, then the basic issue to be addressed is where should imagery best be exploited in order to present the commander with the required imagery information in a timely manner." [14]

However, electronic or digital imagery transmission is communications intensive. The transmission of a single image or photograph at the same resolution at which it was originally acquired can require the transmission of 2-3 billion bits of digital information. Transmission at considerably reduced facsimile quality,equivalent to that of most current decision graphics or select photos can result in the transmission loads of approximately 10-20 million bits of digitized data to reconstruct a single usable image.[15]

The Army 1979 tactical imagery architecture attempted to respond to several imagery systems related management issues including imagery receipt and dissemination; automated interpretation aids and the correlation of imagery with other intelligence; and the echelonment of exploitation facilities to better respond to the needs of individual commanders. Forward looking, it postulates:

" Given the focus on all source intelligence and specifically near-real-time digital imagery, we foresee the need for a tactical imagery exploitation system (TACIES) that receives, processes and exploits all digital imagery without regard to the collecting sensor or platform. ...existing systems represent a first step toward more advanced systems which are expected to overcome [current reconnaissance system] shortfalls."(16)

ENDNOTES

1. US Army Field Manual (FM) 34-1, Volume I (Coordination Draft), Intelligence and Electronic Warfare Operations, Oct 1982, pg 4-11.

2. US Army FM 30-5, Combat Intelligence, Oct 1973, pg 18.

3. US Army Training and Doctrine Command, Tactical Imagery Exploitation, 1979, pg 2.

4. Charles A. Gabriel, Lieutenant General, US Air Force, "Tactical Reconnaissance for the 1980s", Signal (October 1979): 9-11.

5. Ibid., pg 10.

6. Ibid., pg 11.

8. Donald Latham, Deputy Under Secretary of Defense for C3I, "Improving the Tactical C3I Situation-Can We Do It?", Signal, 36 (November 1981):7-8.

9. Melvyn Paisley, Assistant Secretary of Navy, Research, Engineering and Systems, "US Navy Strategic and Tactical $C^3I$ for the 80's",Signal (September 1982):15-25.

10. US Army, Tactical Imagery Exploitation ,pg 2.

11. Interview, Headquarters US Air Force/Intelligence Plans and Systems Directorate, Major J. Lindstrom, Feb 1983.

12. US Army, Tactical Imagery Exploitation, pg 10.

13. Ibid.

14. Ibid.

15. These figures are based upon a 9 x 9 inch frame equivalent and include 5:1 algorithmic compression ratio for "state of the art" data compression techniques. HQ United States Air Force Europe/ Preliminary Operational Employment Concept for the Intratheater Imagery Transmission System (IITS), May 1979.

16. Tactical Imagery Exploitation, pg 13.

## CHAPTER IV

## THE AIR FORCE ROLE IN ARMY IMAGERY SUPPORT

The Joint Chiefs of Staff have assigned a primary mission of the Air Force as the following:

> "To furnish close combat and logistic air support to the Army, to include airlift, support, and resupply of airborne operations, aerial photography, tactical reconnaissance, and interdiction of enemy land powers and communication." (1)

As further defined, the Air Force is charged with providing "strategic and tactical reconnaissance....[and] furnishing aerial photography for use by Army and Air forces.[2] The Air Force therefore clearly has a direct role in providing reconnaissance and photography. What is also clear is that the discharge of this responsibility is directly tied to the servicing of both air and ground requirements.

### EVOLUTION OF THE AIR FORCE ROLE IN RECONNAISSANCE MANAGEMENT

The question of how best to maintain the operational responsiveness of aerial reconnaissance units to supported ground forces is documented as early as World War I. At that time, problems appear to have been centered on issues not

unlike those of today. Precise methods of reporting and communications had to be developed owing to limited radio and ground communications and the ability of the enemy to jam friendly frequencies.[3] Aircraft subordination and and imagery recovery techniques were repeatedly altered in attempts to serve the immediate needs of forward commanders and the more strategic requirements of higher echelons. Varied reporting methods were used to convey misssion results to a variety of recipients: oral and written reports, hand drawn sketches, annotated prints, and overlays.[4] World War II saw little change in the nature of air reconnaissance forces and procedures. In 1941 observation squadrons were transferred to the new air support commands as part of overall air force reorganization. As noted in the Department of the Army official histories at the conclusion of the war, "the question of aerial observation then merged into the larger problem of air-ground support." [5] Control of air observation units was largely centralized at theater or army level with aircraft units normally allocated to corps or division for planning puposes. Major problems were encountered however as reconnaissance units were employed in North Africa.

> "The greatest single handicap to the reconnaissance program as a whole was the absence of a clearly formulated, stable concept of the function of reconnaissance aviation. The particular problems encountered, such as shortage of aircraft and personnel, stemmed from the fact that the program had not been properly planned and organized from the beginning."[6]

Combat in North Africa revealed the weakness of

attaching air attack units to ground command and major efforts began to centralize command, control and operational responsibilities of US air forces. Reconnaissance aircraft continued however,to be responsive to forward ground requirements. Units in North Africa were required to cover the entire army front to a depth of 150 miles each day. Owing to the limited aircraft available, conflicts were bound to occur , and did, in regard to the responsiveness of reconnaissance elements to both ground and air requirments.[7]

Following the invasion of Italy, reconnaissance units were forced to support ground units in Italy from bases in North Africa. This was the result of the relative low priority assigned to the shipment of the large, bulky ground processing equipments of the reconnaissance units. The need for timely reports and imagery however continued unabatted. Special narrative reports were broadcast with preliminary and then summary mission results. Air couriers were used to carry photo prints and photographic mosaics to forward forces. It is significant to note that pinpoint coverage of key targets or terrain was employed, vice previous extensive use of large area coverage. This was done in order to reduce processing and photo delivery times from 48 to 6 hours.[8]

German reconnaissance forces in World War II displayed similar operational and command problems. In the opening days of the war, the Army and Air Force maintained separate reconnaissance efforts. "In spite of careful arrangements to

share results, friction developed" [9] The result was that air reconnaissance reports were consolidated at air fleet and air corps headquarters, along with other intelligence staffs. Tactical air support commands then broadcast reconnaissance summary reports, to include the results of non-reconnaissance missions, three times daily. Later, all reconnaissance was consolidated under the Luftwaffe. This however created additional friction and parochialism as evidenced by the Commander in Chief of the Luftwaffe in 1944:

> "[although the system of centralized reconnaissance management had worked well]... some commands have failed to recognize these interrelations and missions and have not carried our orders in the proper spirit"[10]

Little change is evident in US imagery reconniassance procedures and techniques following World War II and the Korean War. With US entry into the Vietnam conflict, reconnaissance forces initially relied upon phoned or teletyped reports. Army liaison officers were stationed at major Air Force reconnaissance units to "assist in getting [mission reports or results] to field units." However, inherent shortfalls in the responsiveness of film recovery reconnaissance systems and subsequent dissemination of both imagery and reports resulted in the Army placing increasing reliance upon its own organic reconnaissance assets. This soon relegated Air Force reconnaissance to coverage of large area coverage and lines of communication beyond the capability of then growing number of organic Army sensor systems. This divisiveness may also have fostered a rift in

the development of joint ground reporting and imagery dissemination concepts. [11]

The introduction of modern technology unto the battlefields of Vietnam significantly influenced US Air Force reconnaissance efforts in the latter years of that conflict and post-war concepts and development efforts. Three functional areas in particular were to have a profound impact upon Air Force imagery air-ground reconnaissance concepts and support system development efforts: The widespread introduction of automation in intelligence; the use of standardized imagery reports to service a wide variety of recipients; and the development of electronic imagery transmission and dissemination systems.

The introduction of computers in the major command intelligence centers in Vietnam, the Pacific Command headquarters and Pacific Air Command headquarters in Hawaii, and the Defense Intelligence Agency (DIA), which served command authorities in Washington, DC, characterized the gradual evolution of intelligence automation worldwide (Figure 4).[12] With continuation of the Vietnam conflict, tens of thousands of potential installations, road intersections, bridges, and other potential "targets" were meticulously catalogued and committed to extensive automated data bases. Later, enemy order of battle information, equipment types and numbers were also catalogued into yet larger data bases. Both fixed target data and order of battle information was primarily managed, maintained and manipulated by target

number, geographic location or target or object type codes. Batch processing limited the frequency with which data bases could be updated and hence, responsiveness.[13]

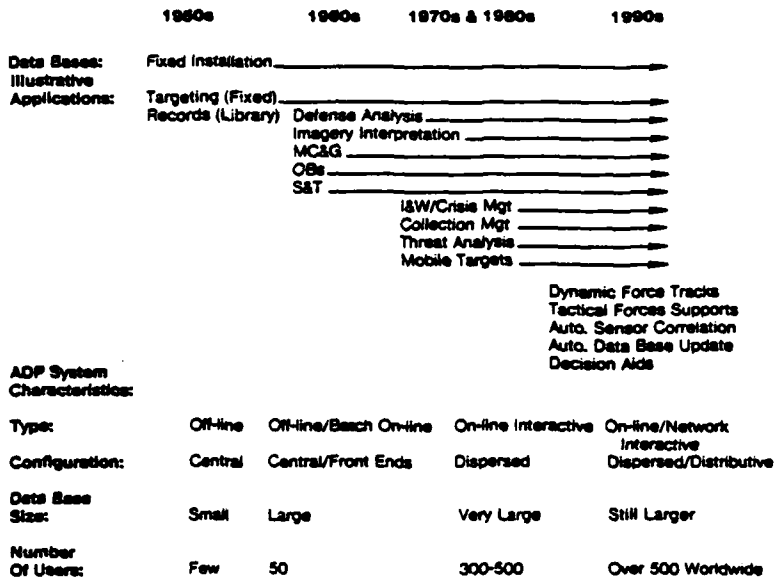


Figure 4. The Evolution of Automated Intelligence Applications (12)

It was the need for computer manipulation of imagery related information which led the Air Force to press for and support the use of standardized, yet highly structured imagery report formats. This effort resulted in the DIA Immediate (later Initial) and Supplemental Photo Interpretation Report (IPIR/SUPIR) formats (DIA Manual 57-5).

Use of the IPIR/SUPIR format made possible the standardization of most imagery interpretation reporting in one "man and machine" readable report. The rigidly formatted, codified nature of these reports readily lent themselves to adaptation to a variety of additional data base

and reconnaissance management codes of little direct utility to air or ground commanders. By 1980, over 77 formatted fields were included in the report with an even greater number of coded data entries. Although many of these entries were optional, they collectively resulted in additional administrative and quality control demands being placed upon reporting units. Since virtually all imagery interpretation units lacked any sort of automated reporting or message generation equipments, theater management emphasis on rigid adherence to format standards actually delayed in-country reporting. Increasing levels of Air Force intelligence automation were thereafter directed toward improving the quality and speed of formatted imagery exploitation reports.[13]

Coincident with developments in imagery intelligence related automation and reporting in Vietnam was the introduction of electronic imagery transmission. Although newspaper and police wirephoto services had been in operation since the 1920s, I found no evidence to indicate that US forces attempted to use electrical facsimile or similar devices for the transmission of reconnaissance imagery in a combat environment until Vietnam. The COMPASS LINK imagery transmission system was introduced to transmit tactical and strategic reconnaissance imagery from Vietnam to the theater headquarters in Hawaii and the National Command Authorities in Washington,DC. Select, enlarged imagery was electronically transformed for digital transmission via

wideband telecommunications. At the receiving end, this process was reversed to produce decision graphics of various types. Actual transmission took only minutes.[15]

It was the relative success of efforts to rapidly transmit combat imagery to higher commands that led the Air Force to endorse development of a transmission system for use by tactical air forces in combat. By 1975, the Air Force had developed an Intratheater Imagery Transmission System (IITS) architecture for the transmission and receipt of select, exploited imagery by tactical air forces world wide (Figure 5).[16]

The IITS system is predicated upon " the transmission of select, exploited imagery from reconnaissance sources to [air and ground] operating units and decision nodes." Several key operational trade-offs are embodied in the employment concept:[17]

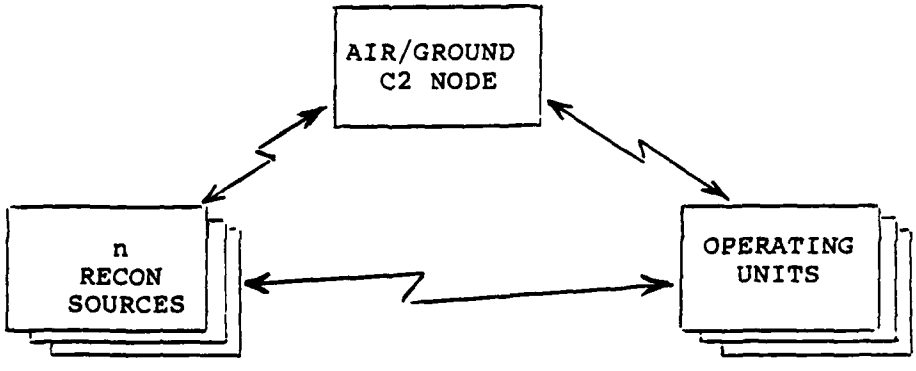


Figure 5. IITS Imagery Transmission Flow Concept.

- Most tactical imagery intelligence requirements can be satisfied by imagery exploitation facilities physically separated from tactical command and intelligence centers. Imagery remains a critical intelligence source. However, most essential elements of information can be satisfied by textual reporting. Imagery and imagery derived graphics augment intepretation reports and provide a valuable contextual reference for command, planning, and weapons employment. Textual reports and selected imagery can effectively augment high resolution, wide area coverage provided aperiodically by less time-sensitive/time-responsive means. Select, exploited imagery would be transmitted based upon request, predetermined essential elements of activity or upon identification of newly developed activity or findings resulting from imagery interpretation. In all cases, the reporting of significant activity or selection of decision imagery is based upon the competence and analytical insight of the imagery interpreter, regardless of his location.

- Imagery must be transmitted at quality levels sufficient to meet varied operational requirements of recipients without resort to further exploitation or enlargement. This required several things: a clear understanding of recipient requirements; exploitation; a management scheme for both image selection and a method by which ad hoc requirements could be serviced.

- System design must be independant of the type or source of imagery. Both imagery and imagery derived data must be available to operational commanders and forces if required to support immediate operational decisions, planning or battle execution needs. Source imagery can include all conventional, infrared, radar imagery, imagery regardless or the type of collection platform, e.g. tactical or strategic. The system must also be capable of transmitting imagery related products and graphics such as aircrew tactical target materials, maps, and threat or operational overlays,

- Transmission must be via narrow band communications media available and programmed for use by tactical forces. This included telephone, radio, troposcatter radio, and shared multiplex tactical satellite channels. This also presented a requirement for the capability to make conscious trade-offs between time, image quality and available combat transmission capacity.

- The network must include ground and air forces. The Air Force must be capable of rapidly disseminating imagery to ground force commanders in a variety of highly mobile tactical environments.

The resulting IITS system design and employment concepts were therefore based upon the transmission of exploited imagery from reconnaissance sources, using joint service TRI-TAC Tactical Digital Facsimile transceivers, and narrow

band communications media. The Army TACIES concept was based upon the transmission or retransmission of original or near-original quality mission imagery from multiple reconnaissance ground sites to exploitation centers located at division, corps and echelons above corps. Communications is to be via wide band communications (Figure 6).[18]

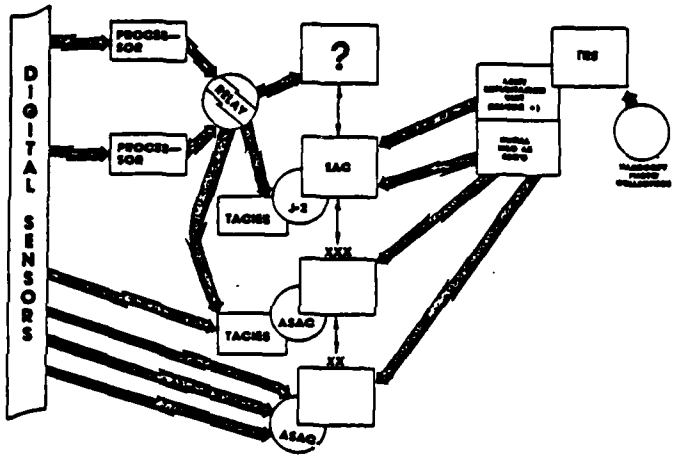


Figure 6. Army Tactical Imagery Exploitation System (Model).

In 1977, the Air Force IITS concept was juxtaposed to then emerging Army TACIES concept. Repeated meetings and discussion between Air Force and Army representatives from major proponent staff agencies failed to reach agreement. Successive deliberation of Unified and Specified command representatives under the auspices of the DIA "Defense Steering Group for Systems Supporting the Transmission, Exploitation and Dissemination of Imagery" also failed tc

reach a consensus among Unified and Specified Command and service representatives.[19]

## INTEGRATION OF IMAGERY INTELLIGENCE WITH OTHER SOURCES

To this point, I have examined the evolution of aerial imagery reconnaissance and discussed both historical and more contemporary impediments to effective support to ground forces. Of particular concern are potential means by which current trends in automation, reporting, and imagery dissemination might be brought to more productive ends. In that these three subject areas deal with information management, they lend themselves to inspection independant of more direct technical analysis. Management and direction of imagery related problems might therefore be amenable to advances or solutions developed in other areas of information management.

> "Intelligence must be timely. The best intelligence is valueless unless it reaches the user in time to serve as a basis for appropriate action. Adherence to this principle may involve some sacrifice of completeness and accuracy in the intelligence product"[20]

In an effort to manage the integrated flow of tactical intelligence on the modern battlefield, the Army developed management concepts for Intelligence, Surveillance, and Target Acquisition (ISTA). The need for ISTA was driven by the quantum increases in battlefield speed and mobility which have drastically reduced the decision cycle for tactical commanders. This comprehensive approach affirmed the need to

match intelligence requirements to the combat task to be supported. Correlation of of intelligence data from multiple sources is used not only to improve the accuracy and completeness of the final intelligence product, but also to reduce the sheer volume of information to be assimilated.[21]

In 1977, the Under Secretary of Defense for Research and Engineering directed a consolidation of heretofore separate yet very similar Army and Air Force intelligence correlation development efforts. The Battlefield Exploitation and Target Acquisition (BETA) project evolved as a feasibility demonstration in the application of automated processing and correlation of multi-source intelligence. Although this project was later terminated as a technology demonstration, it provides a succinct outline of the follow-on Joint Tactical Fusion Program which today continues those initial efforts in a modified form. The objective of the BETA project was to develop technical and management methods to assist in creating an "integrated picture of the battlefield" for ground and air tactical commanders. Its architecture was driven by common Army and Air Force requirements to:[22]

- Provide management for a growing number of intelligence sensors and intelligence products which could not be assimilated in time to effect combat decision.

- Improve the use of limited communications available to tactical forces in combat.

- Improve the effectiveness of air and ground weapons employment by the shared graphic portrayal of hostile force locations and disposition.

- Capitalize on technological improvements to manage near-real-time information needs of the tactical commander which could not be met by current manual means or C3I systems.

The BETA architecture was based upon internetting Army and Air Force reconnaissance system ground processing stations, the Army All-Source Analysis System/Centers at various echelons and the Air Force Enemy Situation Correlation Element or existing theater fusion/correlation centers. Tactical and strategic imagery reconnaissance ground stations were an integral part of this network. Intelligence products, regardless of source were made available to adjacent, higher, and lower correlation centers (CORCENS) based upon preset requirements, e.g. area, type threat or time. These requirements or data threshholds could rapidly be changed electronically to respond to changing battlefield requirements.[23]

A key concept embodied by this approach is the integration and management of varied and widely dispersed Army and Air Force reconnaissance and surveillance sensors and exploitation elements. Interface modules (BIMs) were established at each major reconnaissance source. "BIMSs were used to capitalize on processing capabilities inherent at

ground/sensor processing sites, to filter data [prior to its transmission], and to provide feedback, queing [sensor tip-off or direction] and control".[24]

The distributed processing architecture evidence by the BETA and from it, in the current Joint Tactical Fusion Program does provide fresh insight into potential means of improving Air Force imagery intelligence support to ground commanders.

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24. Kehoe, pg 12.

# CHAPTER V

## CONCLUSIONS AND RECOMMENDATIONS

> "...Dependance on imagery will continue to escalate in proportion to improvements in quality and responsiveness of imagery collection systems and the effectiveness of exploitation management." (1)

Imagery reconnaissance will continue to play a significant and direct role in the support of ground combat operations. Current force levels and investments by the Army and Air Force underscore the importance of imagery derived intelligence to today's planning and execution needs.[2] Historically however, imagery intelligence support operations have been constrained by technical and operational limitations: delays inherent in imagery (film) recovery systems, limited mobility of ground processing equipments, finite communications, and limited capacity to correlate imagery derived information with other intelligence and operations data.

Major advances continue to be made in reducing or eliminating these historic constraints. Selected reconnaissance platforms have been directly subordinated to

ground forces; aerial delivery of film is now possible by direct electronic data link from reconnaissance aircraft; ground processing equipment is becoming more modular and less dependant upon access to large volumes of water; and increased automation and communications are available to expedite dissemination and use of imagery derived reports and products. In the aggregate however, each of these improvements has been matched with growing operational and monetary costs.

## PRINCIPLES OF SUPPORT

By examining historic imagery reconnaissance operations, certain principles emerge regarding critical information needs, exploitation techniques, reporting methods, the need for imagery vice imagery derived information, and service approaches in dealing with continuing constraints inherent in imagery support operations.

- Critical information requirements: Imagery support must be responsive to operational needs for information about hostile forces. Responsiveness can be measured in terms of timeliness, frequency of coverage (and reporting), locational accuracy, level of detail, the types of targets acquired and activity reported, and the intended recipient of the information.[3] The relationship between these factors is a product of the need and ability of the recipient to act upon the information. One additional information element, which

appears as a result of examining historic information needs, and which is not identified in most contemporary literature, is the recurring need to also identify and report the location of friendly forces. This need was evident in World Wars I and IIs, and in operations where the speed and maneuver of forces made discrimation between friendly and hostile forces impossible.

The satisfaction of critical intelligence needs is not confined by source. Imagery does however possess unique attributes and dimensions of detail which provide increased utility as part of an integrated intelligence collection strategy. "...taken singularly or in isolated increments, it is unlikely that any complete or near-complete picture of the battlefield can be developed [by single intelligence sources]."[4] The importance of such data correlation was particularly evident in the inability or failure of theater commanders to effectively correlate imagery reconnaissance reports received from 9th Army Air Corps with operations or other intelligence data prior to the Battle of the Bulge.

- Imagery exploitation: Exploitation is most effective when supported by elements responsive to and cognizant of the operational needs of its supported units. Imagery interpretation is " the process of location, recognition, identification and description of objects, activities, and terrain on imagery"[5] Imagery interpreters respond to tasking in the context of tasked essential elements of information and his or her perception of the criticality of the objects

or activity he or she observes. An interpreter not only reports objects, but their relationship to either perceived norms or previously noted activity. For example, the fact there is no observable activity or enemy force where other intelligence sources indicate otherwise may be of major significance to a pending operation, even though reporting this observation was not a tasked exploitation objective for the interpreter.

Interpretative judgements such as the example above are based upon either tasking or tip-off by other exploitation sources or the interpreters understanding of current operations and enemy contacts. To increase the potential for this type of interaction, either more information must be provided to the interpreter or he or she must be moved to or joined (operationally or electronically) with the source of such information. Collection management strategies and tasking currently provide both specific and generalized exploitation requirements. To be effective, exploitation concepts and systems must support and capitalize upon the image interpreters "sense of the battle." [6] As suggested by the example, exploitation management must also minimize unneccessarily redundant reporting by successive interpreters.

- Reporting methods: Current reporting methods may be improved by review of current reporting requirements and formats and the increased use of graphic reporting or

selected, exploited imagery to facilitate rapid assimilatiion of combat information. The results of imagery reconnaissance may be recorded textually, orally, pictorally, or graphically. Of these, textual reporting has historically been the most prevalent. Army FM 34-1, Intelligence and Electronic Warfare Operations notes that, "Actual imagery is seldom disseminated to the requestor"[7]. In selective cases however, the importance of graphic or pictoral representations has been demonstrated by the willingness of combat commanders to dedicate precious assets for either ground or air courier of imagery and imagery based graphic products.

> "Man as an information processor, is oriented to better understanding and digesting information presented in a graphic or spatially related format as opposed to lists of data".(8)

As evidenced by the evolution of the DIAM 57-5 proscribed joint imagery report formats, the form and content of imagery intelligence formats appear well in excess of requirements for immediate support of ground operations. Data content appears to exceed minimum essential needs of ground combat commanders by a factor of five.[9] This has two immediate, critical results: it unnecessarily taxes already overburdened communications and reduces the ability of the recipient to assimilate key information. On the positive side, structured, formatted reporting facilitates the use of abbreviated information or "brevity coded" data.

Despite efficiencies afforded to various functional activities by a single integrated imagery exploitation report format, additional data not required for direct support of combat operations should not be included in reports intended for direct support of air and ground combat operations. This would minimize unneccessary communication and processing of non-essential data at critical operational levels andfor multiple recipients for whom such data has negative intelligence value (negative in that it reduces their capacity to receive and process information).

A counterthesis is that alternative reporting formats such the HOTPHOTOREP, RECCEXREP, RAINFORM, and several sensor unique abbreviated reporting formats are already available and in use. The difficulty with this is that joint training, support systems design and user education are made less effective by a plethora of diverse forms and are therefore less able to accept, share, and assimilate information which may be critical to coordinated operations.[10]

- The requirement for imagery and imagery derived intelligence: The dissemination of imagery rather than imagery derived information or products continues to be costly despite improved technical capabilities. Imagery as an information source, lends itself to continuing analysis and interpretation. As previously noted, graphic or pictoral information lends itself to rapid assimilation. However, the delivery of imagery, vice imagery derived information has been historically constrained by limited capabilities or

methods for rapid delivery. Where formerly constrained by the ability to physically move aerial film or products, modern electrical dissemination means are constrained by their demands for high capacity communications. As noted by one ground signal commander:

> "Unless communications equipment and capabilities are upgraded, existing [communication, electronic, and computer systems] will play a major calamitous role in the failure of combat commanders on the next battlefield" (11)

- Service "architectural" approachs to imagery support: There is a fundamental disagreement between service imagery architectures evidenced by the Army concept, Tactical Imagery Exploitation: Imagery Intelligence Architecture and the Air Force concept for the Intratheater Imagery Transmission System. Both represent cogent positions. Having reviewed the historic use and evolution of imagery support in air-ground operations, this dichotomy is understandable. It is my opinion that this is initially the result of the limited technical capacity of Air Force reconnaissance to directly and completely satisfy Army requirements for immediate support. Second, it appears that once established, doctrine for Army ground exploitation legitimately can be expanded to encompass the potential for, and from that the requirement for, receipt and exploitation of all imagery sources. Such a requirement appears to provide less regard for the operational costs involved than in the potential marginal gain in benefit. Lastly, the Army and Air Force lack an

common, integrating concept from which to address mutual air-ground imagery support. Commander Richard Pearsall (USN) and Lieutenant Colonel Richard Wheeler (USAF), in a article developed from their study of service reconnaissance and surveillance operations, also observed:

> "...the major impediments to improving [ integrated joint service] information capabilities are human bias, differing service functions, traditions, philosophies and operational doctrine."(12)

A FUNDAMENTAL IMAGERY ARCHITECTURE:

In order to construct an architecture for integrated imagery support, it is useful to construct a generic model of imagery support as evidenced by historic operations and current doctrine. Both air and ground imagery reconnaissance operations include the following functional components: acquisition sensors, receiver/ processors, exploitation elements, transmission/dissemination media, and a recipient (or recipient processor).

- Acquisition sensor/platform: Diverse types of imagery sensors are required to deny the enemy the opportunity for concealment, deception, and freedom of action. Varied sensor platforms will continue to be required due to differing sensor configurations, aircraft payload constraints, range and enemy threats encountered. The current division or operational subordination of reconnaissance platforms between the Army and Air Force is based more on the need for

force management and responsive operation of the imaging platform rather than on current concepts of imagery processing and reporting.

- Receiver/processor: Imaging sensors record unique physical phenomena. The recording medium, e.g. film or digital signal, must be processed into a coherent form intelligible for human interpretation. Despite advanced technology, many of our sensors require unique, ground based processors. Most processors are costly, large in size and expensive to maintain. At the extreme end, the TR-1 ground processing and control equipments consists of "several" 8x8x14 foot transportable modular shelters, the WS-430B ground processing system for RF-4C conventional film-based imagery systems is currently comprised of 26 8x8x14 foot shelters. Although this reflects a potential trend resulting from electronic vice conventional image processing, the overall impact on mobility and target signature continues to be significant. Probably the greatest impact however is the significant corresponding growth in the requirement for technically demanding maintenance and operation support.[13]

Until processed, the imagery sensor data stream remains unique to a specific type of sensor and therefore requires specialized ground processing. Once processed however, data can be transported into a common digital format. The Army Imagery Architecture appropriately envisions the capability to receive potentially all available digital imagery sources for subsequent electronic manipulation and exploitation.

There is currently no evidence however, of planning or specifications for a common digital format which would lend itself to this approach.[14]

In addition to digital imagery data, reconnaissance platforms and sensors record ephemeral information which identifies the position of the imaging platform, pointing angles and other reference data critical to exploitation and computations required to locate imaged activity. This data is particularly important for exploitation of long range imagery of small targets or areas of activity for which other ground references are not apparent. Ephemeral data is separate and distinct from transmitted imagery signals and must also be processed and identifiably coded for use.

- Exploitation elements: As electronic imaging sensors have become more and more complex, so too have the requirements for ground exploitation elements. As sensor capabilities and the tempo of ground operations have increased, so too has the demand for more responsive exploitation. As previously noted, the TR-1 will be capable of imaging tens of thousands of square miles of hostile territory/forces and literally hundreds of thousands of objects and potential targets. The Army design concept for the former Stand-off Target Acquisition System (SOTAS) radar system, a predecessor to the current concept for the Joint Surveillance Target Acquisition Radar System (JSTARS) called for an imaging radar to detect moving targets in the forward

area. SOTAS would alone have, "...increase[d] the number of artillery targets detected beyond 15 kilometers of the forward edge of the battle area by a factor of 3".[15] If some method is not devised to synthesize or reduce the volume of imagery or imagery derived targeting data, the following assessment is fully warranted:

> "The acquisition and movement of information does not guarantee a more capable force or increased combat effectiveness. If not managed properly, the flow of information might inundate the commander and his staff."[16]

Rather than increasing the number and size of imagery exploitation elements, its appears that it would be more prudent to develop combined air/ground exploitation elements capable of "processing at the source" to reduce the flow of unevaluated and potentially redundant data to command centers and other tactical users.[17] This approach would not obviate the need for certain imagery based sensors to be integral elements of immediate response fire control systems, but would make possible immediate benefits in improved communications, data correlation, technical support and overall support of combat users. A "source processing" methodology is consistant with advanced development efforts directed under the Joint Tactical Fusion Program previously discussed in Chapter IV and follows an historic trend in which "since World War II, the tactical commander has become increasingly dependant on externally located intelligence centers for information on enemy activity"[18]

The antithesis of course, is that by removing the exploitation element from the commander we reduce its responsiveness and therefore increase his vulnerability. This argument must be viewed based upon overall benefits and risk . It is not supported by current doctrine. Field Manuals (FM) 34-1 and 100-16, identify corps and echelons above corps as the interface point for national and other service imagery sources. Centralized filtering therefore already reduces the information flow and responsiveness to division and other forward operational elements. FMs 11-50, 11-92, and 100-5 dealing with communications planning and command post operation and survivability, also identify the need to reduce communications loading, increase command dispersion and displacement and to reduce the overall target signature of command elements. This encourages physical dispersal of main and tactical operations centers and mitigates the immediate responsiveness of potential direct support elements.

- Transmission media: Probably the most critical element in any architecture involving digital transmission or relay of imagery is the availability of adequate communications to support its implementation. As early as 1962, the Army Electronics Command developed A Feasibility Study of an Army Combat Surveillance Satellite System.[19] Given unclassified "state of the art" estimates of digital imagery data rates, projected transmission rates consumed major percentages of currently available Defense Satellite

Communications System (DSCS) communications relay satellite capacity. This contrasts vividly with the conclusion reached in the Army Tactical Imagery Exploitation concept which justifies the receipt of imagery at corps via digital communications with the following:

> "Imagery provided to the corps in an NRT digital mode for exploitation at corps can meet the timeliness requirements of the corps commander, while reducing the communications dependence inherent with exploitation results being transmitted to the corps by message from a distant exploitation facility"(underscore added) (20)

Army and Air Force concepts differ markedly on the need for select, exploited imagery. The Tactical Imagery Exploitation concept currently identifies the need to colocate select Army imagery interpretation units (subordinate to echelons above corps) with Air Force reconnaissance units to speed the exploitation of less timely, conventional imagery systems. Mosaics and similar products will also be prepared for subsequent dissemination to ground units by courier. Colocated Air Force units will be equipped with Intratheater Imagery Transmission System (IITS) terminals linked with the Air Force Tactical Operations Center at Corps. There are presently no plans however, for combined use of this capacity.[21]

- Recipients/recipient processors: Effectively managed, integrated ground processing elements can reduce the possibility of overwhelming the commander, his command and control systems and the available communications which support him. As proposed by Assistant Secretary of the Navy

for Research, Engineering and Development, Dr. Melvyn Paisley, effective correlation and processing of data at the information source:

> "allows the limited communications spectrum to be used for providing protected antijam communications and not wasted transporting vast quantities of unevaluated and undigestible data....and enables development of multiple path routing networks for critical information."(22)

## RECOMMENDATIONS

The following recommendations, not necessarily within the scope of this thesis, appear evident as a result of its development. These recommendations are provided for potential response or further research.

- There needs to be a jointly developed architecture for imagery exploitation, reporting, and dissemination. This effort should establish concepts for jointly manned and operated imagery exploitation activities/units. Such units would be designed to support the receipt and interpretation of digital and non-digital imagery regardless of acquisition platform. Combined operations would increase mutual sensitivity to the information needs of supported units regardless of which service actually acquired the source data. Other immediate benefits of combined operations could be realized through the integration of currently isolated and largely redundant interpretation facilities (people, equipment, technical support and security), reduced

exploitation mangement overhead, and reduced communications requirements (both for the transmission of raw imagery and resulting reports or products).

- The combined air-land imagery architecture above should establish requirements for select, exploited imagery and other graphic representations (overlays, computer graphics, tracking reference grids, et cetera) as a cost and operationally effective alternative means for disseminating imagery derived combat information and intelligence to division and lower users users. Graphics and select, exploited imagery can synthesize or augment textual reporting to many users. Select, exploited imagery could also supplant most requirements for high resolution imagery at corps and division. In my opinion, Army and Air Force concepts for operational employment of the joint TRI-TAC Tactical Digital Facsimile (AN/UXC-4 vice AN/UXC-7) should include the need for transmission of imagery intelligence and other graphic intelligence products between services. It appears mutually advantageous to employ common, available equipment to satisfy immediate operational needs.

- Imagery exploitation elements must be provided responsive links with other information sources and supported units to facilitate ad hoc or situationally dependant reporting. It is inconceivable that all potential imagery exploitation requirements can be foretold. Most critical needs will continue to result in an evolving manner based

upon the nature of the battle. Tactical situation displays such as those currently programmed under the Joint Tactical Fusion Program should not be limited to ground and air command and control centers. Integrated, all-source intelligence and operations data displays must be provided to exploitation management control centers to convey a sense-of-the-battle as an integral element in guiding ad hoc or time-critical exploitation and reporting.

- DIAM 57-5 imagery reporting formats should be reduced in content to minimum data elements of: time, coordinates, observed activity, and a single administrative control number, e.g. Basic Encyclopedia or World Area Grid (WAG) cell. Reports should be source-processed by activity type and user defined geographic area of interest, at the exploitation activity and prior to dissemination. Supplemental data not required for immediate combat operations should be separable or dispatched to specific functional activities by separate means.

- A common technical baseline should be established for the transmission and manipulation of digital imagery and supporting ephemeral data. This would allow the development supporting exploitation, image enhancement, and communications hardware and software from a common technical baseline, regardless of acquiring platform or service.

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6. The origin of this term is unknown to the author. It identifies a special level of vicarious insight and understanding of operational needs judged to be the result of proximity to battlefield operations or major sources of information.

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